ET47

ELECTRICAL WORKERS
REGISTRATION BOARD
Safety • Competency

Candidate Code No.

For Board Use Only

Result	Result
Date	Date
Int	Int

ELECTRICIAN'S THEORY EXAMINATION

16 November 2013

QUESTION AND ANSWER BOOKLET

Time Allowed: Three hours

INSTRUCTIONS – READ CAREFULLY

You have 10 minutes to read this paper but do not start writing until you are told to do so by the supervisor.

Write your Candidate Code Number in the box provided above. Your name must NOT appear anywhere on this paper.

Answer all questions.

The pass mark for this examination is 60 marks.

Use a pen for written answers. **Do not** use a pencil or a red pen.

Drawing instruments and pencils may be used when diagrams are required. Marks are allocated on the basis of correctness.

Do not use correcting fluid or correcting tape.

For calculation questions all workings, including formulae, must be shown to gain full marks.

Non-programmable calculators may be used.

Warning – You could get 0 marks for any question, or part of a question, if you show anything hazardous or dangerous in your answer.

Candidates are not permitted to use any Act, Regulation, Standard, Code of Practice, Handbook or other reference text in this examination.

PLEASE HAND THIS PAPER TO THE SUPERVISOR BEFORE LEAVING THE ROOM.

(turn over)

Question 1

(a) (i) State the main advantage of a single-phase synchronous motor when compared to a single-phase induction motor.

(1 mark)

(ii) State **TWO** reasons for using reduced-voltage starting for the three-phase induction motor.

(1 mark)

(1)

(2)

(b) (i) Describe how the output voltage of a large power transformer is maintained as the load changes.

(1 mark)

(ii) Explain the term **burden** as it relates to current transformers.

(1 mark)

(turn over)

Question 1 continued

(c) State **TWO** methods of **phase-splitting** used to provide the starting torque in a single-phase induction motor.

(2 marks)

(1) ____

(2) ____

(d) State **TWO** devices that can be used to protect semi-conductor components against the effect of transient voltages.

(2 marks)

(1) ____

(2) ____

(e) State **TWO** factors that determine the voltage drop in a 400V, final subcircuit TPS cable.

(2 marks)

(1) ____

(2) ____

(turn over)

Question 1 continued

(f) A three-phase squirrel cage induction motor is running **fully-loaded**.

State the **main effect** on the operation of the motor if the supply voltage drops.

(2 marks)

(g) State the reason why an HRC fuse would be installed up-stream of the MCBs on a switchboard in an existing single-phase commercial installation.

(2 marks)

(h) State what would occur if a 230V, single-phase capacitor-start motor that was running suddenly experienced a 50% drop in speed due to mechanical overloading **and** the electrical protection failed to operate?

(2 marks)

(turn over)

Question 1 continued

(i) State **TWO** reasons why an RCD tester is used to test a **PRCD**.

(2 marks)

(1) ____

(2) ____

(j) (i) State **ONE** hazard that could occur when using a multimeter to measure output voltages in high-pressure sodium-vapour lamp control circuits.

(½ mark)

(ii) State **ONE** hazard that could occur if low-pressure mercury vapour lamps (fluorescent tubes) are broken during disposal.

(½ mark)

(turn over)

Question 1 continued

(iii) State **ONE** hazard that could occur when disposing of low-pressure or high-pressure sodium-vapour lamps.

(½ mark)

(iv) State **ONE** hazard that could occur when operating a HID metal-halide lamp with the lamp's outer envelope broken.

(½ mark)

(turn over)

Question 2

(a) Figure 1 shows an earth-fault loop impedance tester plugged into a 230V socket outlet in an electrical installation. The socket outlet is protected by a 20A HRC fuse.

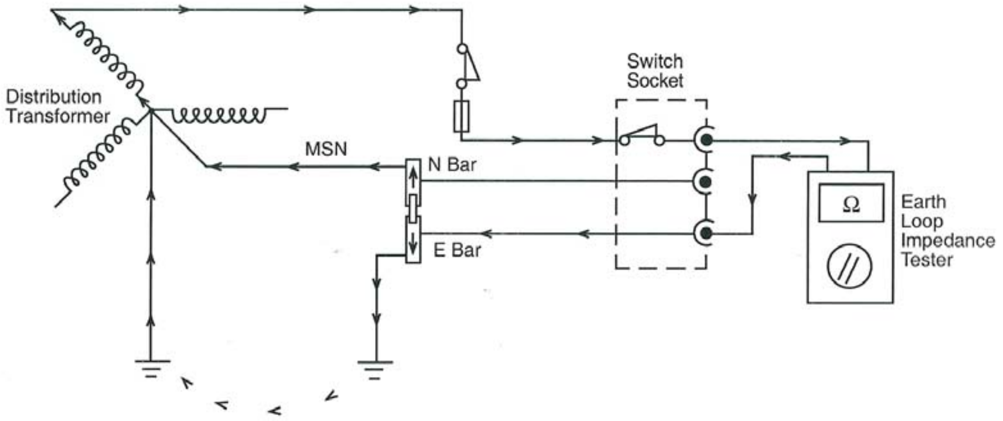

Figure 1

(i) State the reason why the earth-fault loop impedance test is carried out at the socket outlet

(2 marks)

(ii) State the reason why an earth-fault loop impedance test is **also** carried out at the switchboard of the electrical installation in Figure 1.

(2 marks)

(turn over)

Question 2 continued

(b) Figure 2 shows time/current characteristic curves for a thermal overload device and an HRC fuse that protect a motor circuit.

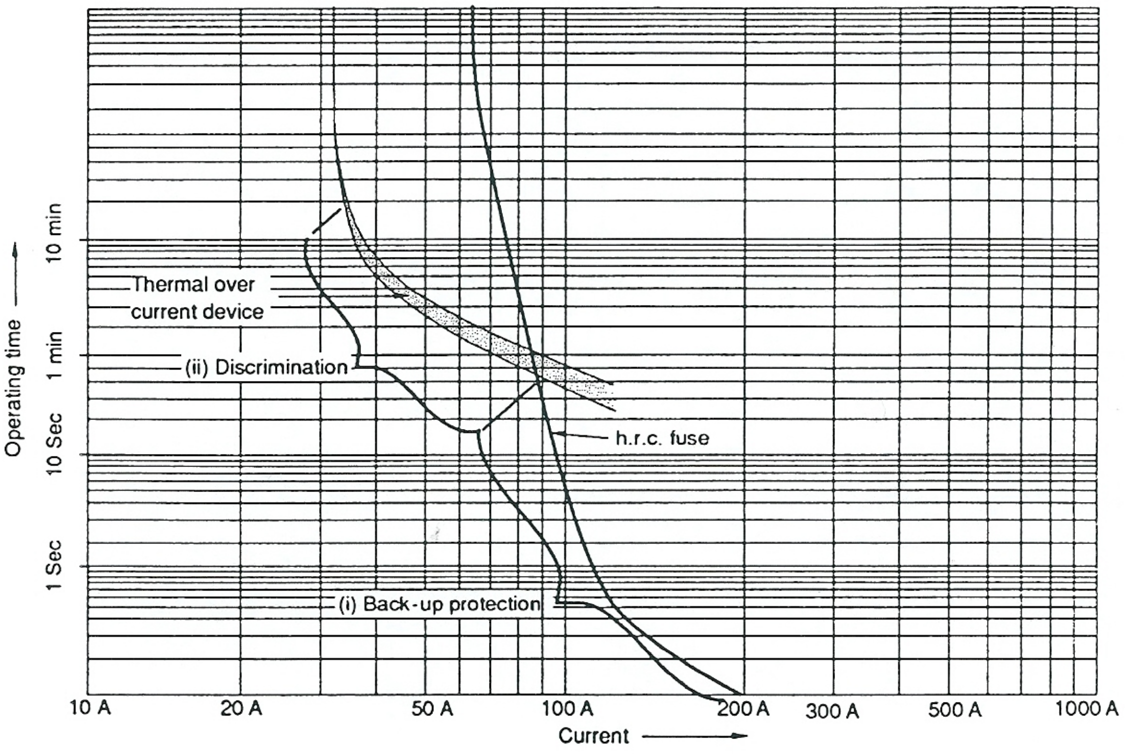

Figure 2

(i) Refer to Figure 2 and describe what would occur if the motor was to draw a line current of 70A.

(1 mark)

(ii) Refer to Figure 2 and describe what would occur if a fault current of 150A developed on the motor circuit.

(1 mark)

(turn over)

Question 2 continued

(iii) Refer to Figure 2 and compare the operating times of a 70A HRC fuse and a 150A HRC fuse.

Demonstrate how the inverse time/current characteristic occurs by using the operating times of the 70A HRC fuse and the 150A HRC fuse as examples.

(2 marks)

(c) Describe what occurs in an electrical installation when a fault occurs in an electrical installation and there is **correct discrimination** between two electrical protection devices in the electrical installation.

(2 marks)

(turn over)

Question 3

(a) (i) Draw and label a circuit diagram of a **three-phase full-wave bridge rectifier** connected to a resistive load.

- Show the three-phase incoming supply.
- Show the polarity of the load

(5½ marks)

(ii) State the ripple frequency of the output of the rectifier in (a)(i), if the input is 400V, 50 Hz

(½ mark)

____

(iii) State **TWO** components that can be used as a filter in the rectifier circuit in (a)(i).

(1 mark)

(1) ____________________________________

(2) ____________________________________

(turn over)

Question 3 continued

(b) (i) Draw a circuit symbol for a **voltage dependent resistor (VDR)**.

(1 mark)

(ii) State the main function of a **voltage dependent resistor (VDR)**.

(½ mark)

(iii) Describe how a **voltage dependent resistor (VDR)** carries out the function stated in (b)(ii).

(1 mark)

(iv) State where in a circuit a **voltage dependent resistor (VDR)** is connected.

(½ mark)

(turn over)

Question 4

Introduction

A 230V transformer with a step-down ratio of 20:1 is used to supply electric toys. The transformer has 2000 turns on the primary. The primary draws 2A when fully loaded.

Use the information in the introduction to this question to answer parts 4(a), 4(b), 4(c), 4(d) and 4(e).

(a) Calculate the number of secondary turns of the transformer

(2 marks)

(b) Calculate the secondary voltage of the transformer

(2 marks)

(c) Calculate the volts per turn of the transformer

(1½ marks)

(turn over)

Question 4 continued

(d) Calculate the VA rating of the transformer.

(1½ marks)

(e) The transformer is a double-wound type.

(i) State the **main** reason why the transformer is double-wound.

(1 mark)

(ii) State the **TWO** reasons why an auto-transformer is not used for this application.

(2 marks)

(1)

(2)

(turn over)

Question 5

Introduction

A new three-phase water heater has been installed in a dairy shed to replace an existing unit.

The new water heater has three, 230V/400V elements each with a resistance of 30Ω. The heater can be connected in star or in delta.

The existing 2.5 mm^2 TPS final subcircuit cable for the water heater is protected by 20A rewireable fuses.

Use the information in the introduction to answer parts 5(a), 5(b) and 5(c).

(a) Use calculations to show that **star** is the correct connection method if the **existing** final subcircuit cable and protection is used.

(5½ marks)

(turn over)

Question 5 continued

(b) Calculate the power consumed by the heater using the **star** connection method.

(2 marks)

(c) (i) State the simplest change that can be made that would allow the water heater to be connected in delta.

(1 mark)

____

____

(ii) Calculate the power consumed by the heater using the **delta** connection method.

(1½ marks)

(turn over)

Question 6

(a) Draw and label a diagram of a 230V single-phase capacitor-start, capacitor-run induction motor.

(4 marks)

(turn over)

Question 6 continued

(b) From the circuit drawn in (a) describe the operation of this motor from the time it is switched on until the time it reaches full speed

(5 marks)

(c) State the main reason why a single-phase capacitor-start, capacitor-run induction motor would be used to drive a large air-conditioning fan, instead of a split-phase motor of the same rating.

(1 mark)

(turn over)

Question 7

Introduction

A 400V, three-phase, 2kW water pump, isolating switch, DOL starter and final subcircuit wiring have been installed but **are not connected to the switchboard.**

The order of connection of the final subcircuit is - from the switchboard to the isolator; from the isolator to the DOL starter; and from the DOL starter to the pump motor.

Use the information in the introduction to this question to answer Parts 7(a) and 7(b).

(a) State the **FOUR** tests using test instruments that need to be carried out to ensure the motor and final subcircuit are safe to connect to the electricity supply.

(2 marks)

(1) ____

(2) ____

(3) ____

(4) ____

(turn over)

Question 7 continued

(b) **Three tests** stated in (a) **can only be carried out** with the motor and final subcircuit **disconnected**.

For each of those tests state:

- The test instrument used
- The test voltage, if applicable
- How the test is carried out
- A test result that permits connection to the power supply

(8 marks)

(turn over)

Question 8

(a) Draw and label a circuit diagram of a 230V RCD used for personal protection. Include the Class I equipment as the load.

The RCD must include all the components necessary to allow the RCD to be deemed **electrically safe**.

(4 marks)

Single-phase RCD

Class I equipment

(turn over)

Question 8 continued

(b) State the **maximum permitted** rated residual current of an RCD installed for:

(i) Personal protection in a domestic installation.

(½ mark)

(ii) Personal protection in a medical-electrical installation.

(½ mark)

(iii) The protection of property.

(½ mark)

(c) State the reason why Type **AC** RCDs are prohibited from being used in New Zealand.

(1 mark)

(turn over)

Question 8 continued

(d) (i) The phase and neutral on the supply side of a single phase RCD have been transposed.

Would the RCD operate if it detected an earth leakage fault on the circuit it protects? State a reason to support your answer.

(1 mark)

(ii) Would an RCD operate if there was a short between neutral and earth on the final subcircuit it protects? State a reason to support your answer.

(1 mark)

(e) State the full names for the following terms:

(1½ marks)

PRCD

RCBO

SRCD

(turn over)

Question 9

In New Zealand the MEN distribution system is used.

(a) State **TWO technical** reasons why the neutral conductor is earthed in the MEN system.

(2 marks)

(1) ____

(2) ____

(b) A main switch for a 400V, 50 Hz, three-phase supply is rated at 20 MVA.

Calculate the maximum short-circuit current that the main switch can safely open under fault conditions.

(2 marks)

(turn over)

Question 9 continued

(c) A 230V, Class I, dishwasher is used in an earthed situation.

Explain how the effective earthing of the metal frame of the dishwasher provides protection against electric shock.

(3 marks)

(d) State **TWO** factors that limit the prospective short-circuit current in an electrical installation.

(2 marks)

(1)

(2)

(turn over)

Question 9 continued

(e) State the main reason why **Class II (double-insulated)** electrical equipment **is not** required to be connected to a protective earthing conductor.

(1 mark)

For Candidate's Use

In the box, write the number of **EXTRA** sheets you have used. Write **NIL** if you have not used any

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Questions Answered	**Marks**	
1		
2		
3		
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7		
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TOTAL		